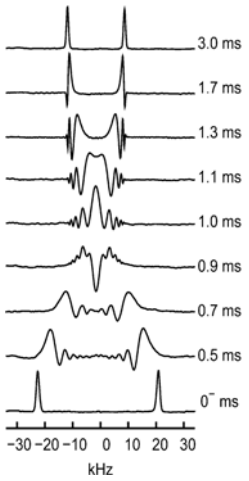
Field-induced alignment of the liquid crystal director

Anu M. Kantola[a], Geoffrey R. Luckhurst[b], Akihiko Sugimura[c], Tohru Tanaka[c], and Bakir A. Timimi[b]

[a]*Department of Physics, P.O.Box 3000, FIN-90014 University of Oulu, Finland*
[b]*School of Chemistry, University of Southampton, Southampton, SO17 1BJ, UK*
[c]*Department of Information Systems Engineering, Osaka Sangyo University,3-1-1 Nakagaito, Daito-shi,Osaka 574-8530, Japan*



One of the key quantities controlling the response times for liquid crystal displays is the rotational viscosity for the motion of the nematic director [1]. There is, therefore, considerable interest in measuring this quantity for nematic liquid crystals and a variety of techniques have been developed to achieve this [2]. Time-resolved deuterium NMR spectroscopy has proved to be a powerful method to investigate the field-induced rotation of the director in a nematic liquid crystal. In this experiment the quadrupolar splitting is measured as a function of time after the electric field has been switched on or off [3]; from the quadrupolar splitting it is possible to determine the director orientation with respect to the magnetic field of the spectrometer. The time dependence of this orientation then gives the relaxation times, either τ_{ON} or τ_{OFF}, from which the rotational viscosity coefficient can be extracted [4]. However, for the experiment to be applicable it is necessary that the director orientation and hence the quadrupole splitting does not change significantly during the acquisition of the FID which is subsequently Fourier transformed to give the NMR spectrum. We have extended the method to systems where this requirement is not satisfied and the observed NMR spectra are now found to contain novel oscillatory features instead of a single quadrupolar doublet [5]. The direct determination of the director orientation in the presence of such spectral oscillations is not possible. To see how information concerning the director orientation might be obtained as well as to understand these oscillations we have developed a model combining both director and spin dynamics. In addition to increasing the information content of the time-resolved NMR spectra it also proves possible, under certain conditions, to determine the field-induced relaxation time from a single spectrum instead of a series of spectra, as has been the case with previous studies [3, 4].

We report the results of experiments designed to demonstrate the oscillations in the deuterium NMR spectra for 5CB-d_2 and the striking form that may they adopt [6]. The validity of the theory is confirmed by the good agreement found between the simulated and experimental deuterium NMR spectra. This combination of experiments and simulations also allows us to determine the director relaxation times.

References

[1] E. Jakeman and E. P. Raynes, *Phys. Lett.,* **39**, 69 (1972).
[2] See, for example, J. K. Mosciki in *Physical Properties of Liquid Crystals: Nematics* Eds. D. A. Dunmur, A. Fukuda and G. R. Luckhurst (INSPEC, IEE, London, 2001) Chapt 8.2.
[3] G. R. Luckhurst, A. Sugimura, B. A. Timimi and H.Zimmermann, *Liq. Cryst.*, **32**, 1389 (2005).
[4] C. J. Dunn, G. R. Luckhurst, B. A. Timimi and A. Sugimura *Mol. Cryst. Liq. Cryst.*, **347**, 167 (2000).
[5] A. M. Kantola, G. R. Luckhurst, T. Miyamoto, A. Sugimura and B. A. Timimi, *Mol. Cryst. Liq. Cryst.*, **402**, 117 (2003).
[6]. A. M. Kantola, G. R. Luckhurst, A. Sugimura, T. Tanaka, and B. A.Timimi, *Submitted for publication in the Journal of Chemical Physics*